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INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION

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Director

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ANNUAL REPORT OF THE INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION FOR 1945

RANGE RESEARCH

Because rangelands of the Intermountain region are in various degrees of depletion and deterioration, the urgent practical problem today is one of building up the forage supply and stopping further soil loss from accelerated erosion. In this problem, the task of range research is one of finding ways to increase vegetation, both as forage and as protective cover.

At the present time, two broad methods of attack have developed for this problem. One is, by judicious management, so to control grazing that the native vegetation responds by increasing in volume or in quality. The other, applicable especially to areas in such critical condition that natural processes of recovery are too slow to be effective, and to areas where speedy restoration is justified on economic grounds, is to establish vegetation by direct seeding treatments.

Accordingly, range research at this station is conveniently divided into two fields. One is Grazing Management, the province of which is primarily research toward range improvement through better understanding of native range. The second is Artificial Reseeding, the province of which is research toward range improvement through knowledge of species and procedures by which vegetation may be increased by cultural means.

GRAZING MANAGEMENT

Summer Range

Summer range occupies only a little more than one-fifth of the total area of range land in the Intermountain region, some 31 out of 146 million acres. Its strategic importance is much greater than this proportion would suggest, however. First, summer range forms a vital link in the yearlong livestock operation, furnishing the forage on which annual weight gains and growth of young animals are made. Second, summer range is primarily mountain range, where conflicts with other land values--particularly watershed values--are most serious.

Because of their great areal extent there is wide latitude for variation in winter range and spring-fall range in the Intermountain region; but in the case of summer--mountain--range, variation is enormously greater. Superimposed upon variations in climate, soil, and vegetation to be expected within an areal extent of some 10 degrees of latitude and 11 degrees of longitude, are variations in mountain range accompanying altitudinal changes in a single locality up to a mile and a half, variations with exposure to any point of the compass, and variations with slope steepnesses from zero up to 100 percent.

Clearly the problems of mountain range, the chief of which will be outlined briefly here, are of a kind to challenge the land manager's utmost efforts, both from the standpoints of the difficulty of their solution, and of the values involved. Since most mountain range in this region is under national forest administration, management research on mountain range is of particular interest to the Forest Service because it ties in directly with the Service's determination "to get on top of" its range problem.

Broadly, the problem in administering mountain range is to balance stocking with grazing capacity, at the same time reconciling grazing with other wildland uses. The specific problem on a given area requires that the land manager understand the effects of animals, domestic and wild, on that kind of range, that he be able to evaluate the condition of that range in relation to its potential, and that he be able to judge whether or not current management measures are bringing about the changes he desires. The job of summer-range management research is to discover facts and principles to answer specific questions in these fields.

The research attack is outlined briefly here under four heads. These have to do, first, with developing standards for judging range condition and trend, secondly with increasing plant cover, thirdly with understanding the relation of animals other than livestock to the range, and fourthly with formulating a comprehensive problem analysis for research on these important range-watershed lands.

Develop standards for judging range condition and trend

The first work on range condition and trend was Sampson's study on succession in the subalpine zone of the Wasatch Plateau, published in 1919. In 1939 Clark and Hansen prepared a mimeographed utilization handbook for the Intermountain Region. In 1944 Ellison and Croft prepared Research Paper No. 6 on judging condition and trend of high range-watersheds.

During 1945, as in the last several years, station personnel assisted the Region in its condition-and-trend training program, instructing forest supervisors and rangers in recognizing and reasoning with indicators. The manuscript on judging condition and trend was revised and submitted to Washington, and comments from board of review have been received.

After the condition and trend manuscript is made ready for publication, the general principles of judging condition and trend on subalpine range in this region will have been outlined so far as present knowledge allows. Further progress in development of principles, particularly in the use of plant indicators, will require detailed information on the ecology of specific types. For a beginning the successional studies that were begun by Sampson and that have been carried forward in recent years, will be completed. As funds permit, other specific types will be investigated throughout the region. An attack on the aspen type and its subtypes is being planned by the Utilization Standards work project, as discussed elsewhere in this report.

Field work during 1945 on the ecological-condition study was mostly devoted to finding examples of undisturbed subalpine range on the Wasatch Plateau for comparison with grazed range. By means of aerial photographs, three fairly suitable areas were found. Although all are now probably overstocked with game, they are in so much better condition than the range accessible to livestock that they are of great value in reconstructing the character of the original vegetation.

Completing revision of the condition and trend manuscript for publication is the first-priority job for the summer range work project in 1946. This revision will be finished before summer. The field work of the project during 1946 will continue to bring toward completion the ecological-condition survey of the subalpine zone of the Wasatch Plateau.

Increase plant cover

The ecological studies referred to in the last paragraphs relate directly to the problem of increasing plant cover, since it is through an understanding of ecological relationships that increase in plant cover can be brought about by management.

Plot studies in the vicinity of the Great Basin Branch Station give considerable information on changes in plant cover in response to changes in rate and class of stocking. These studies are being combined with more extensive observation in the subalpine zone of the Wasatch Plateau, as mentioned in the last section, in order to bring up to date the story of grazing and plant succession in this subalpine type. Thus, research effort at this station on the problem of increasing plant cover parallels and is part of ecological research on indicators and plant succession, outlined above.

Evaluate biotic influences

The relation between livestock and big game is being taken up elsewhere in this report, since it is a problem which affects spring-fall and winter range, as well as summer range. Another biotic influence on summer range, which is subject to considerable debate, is the pocket gopher. About the pocket gopher two questions are commonly raised: What part does he play in the formation and erosion of mountain soils? To what extent is he a competitor with grazing animals for forage?

A discussion of the first question, on the basis of several years' observations in the subalpine zone of the Wasatch Plateau, will be published in ECOLOGY during 1946. Briefly, the findings are that the pocket gopher is a natural agent in soil formation and normal geologic erosion. He is not a primary cause of accelerated erosion, but does augment accelerated erosion greatly on ranges where the plant cover has been depleted and infiltration capacity of the soil reduced in consequence of overgrazing.

As for the second question, on competition for forage with grazing animals, no conclusions have yet been reached. A cooperative study was undertaken on this question with the Fish and Wildlife Service in 1941. An enclosed 4-acre area was set up on half of which pocket gophers have been trapped out. A weight inventory of vegetation was made in 1941, and a second one was made in 1944. From the analysis of these data last year, no significant trends could be detected.

What remains to be done on the pocket-gopher question may be as broad and long as the Intermountain region, for investigations to date have been limited strictly to part of the Wasatch Plateau. How widely applicable the answers found there will be is something that remains to be determined. For the coming year, limitations in funds and personnel will permit only continued maintenance of the enclosed study area and extensive observations on pocket-gopher ecology.

Analyze problems of mountain range

This heading is different from the preceding three in that it does not seem to point to an immediate administrative need, but, rather, to a specific research need. Actually, it does both. A comprehensive knowledge of summer-range problems, lacking in any degree of detail at the present time, is essential to a research attack that will be of maximum utility to national forest administration. As an example, consider the foregoing comments on the uncertainty as to the extent and seriousness of the pocket-gopher question in the region. Again, a research attack by broad range types, mentioned earlier, is necessarily based upon extensive knowledge of what types there are, and of what features of each are in most need of study.

A region-wide problem analysis for summer range is not easily made, and has not been made (at least during the last decade or two), for three reasons. First, mountain ranges are mostly hard to get to and to cover; the inspection of even a small piece of range requires a good deal of time. Second, mountain range is extremely variable, its character in one spot being wholly different from that in another only a few miles away, so that an adequate inspection of mountain range in the Intermountain region is a major undertaking. And third, work-project effort has largely been confined, in part by lack of funds, to studies already under way in the vicinity of the Great Basin Branch Station. The field work done by Ellison in 1942, in connection with his and Croft's study of range indicators, was the first opportunity, at least in recent years, to acquire an extensive picture of national forest range conditions and problems.

It is planned, as one result of the reorganization of the range research division of this station, to develop a problem analysis of summer range. This problem analysis will necessarily be built up, as opportunity for systematic observation occurs, over a period of years, because a full schedule of going work, plus limited funds, continue to restrict project activity.

Spring-Fall Range

The spring-fall ranges of the Intermountain region form an important tie in the yearly pattern of migration from winter feeding grounds to high summer ranges and back again. Totalling about 50 million acres, they occupy the vast Snake river plains of southern Idaho, and the foothills and the lower slopes of the mountains in the Great Basin and Colorado river drainages. The climate of the spring-fall range territory is generally mild with average annual precipitation varying from 8 to 20 inches. Most of the soils are productive.

Much of the spring-fall range is covered with big sagebrush (*Artemisia tridentata*), but there are also extensive acreages, where sagebrush has been destroyed by fire, now occupied by nearly pure stands of cheatgrass (*Bromus tectorum*). On areas which have not been abused by overgrazing and indiscriminate burning, the understory consists of mixtures of grasses and weeds.

Because they are closer to farms and settlements than either summer or winter ranges, and because grazing on summer and winter ranges is generally limited by regulation, spring-fall ranges, many of which are in private ownership, are highly vulnerable to abuse. Today they produce only a small part of their potential forage, and are considered the critical part of the year-round forage picture.

Several important problems exist which, if solved, would bring spring-fall ranges more nearly up to full productive capacity. These problems include: (1) increasing the productivity of sagebrush range by reducing sagebrush; (2) evaluating cheatgrass for spring-fall range; (3) balancing stocking against the forage supply; (4) determining proper distribution of use; and (5) determining proper season of use.

The facilities of the Intermountain Forest and Range Experiment Station for studying the problems of spring-fall range have been largely limited to cooperative activities with the Bureau of Animal Industry at the U. S. Sheep Experiment Station, Dubois, Idaho, at the extreme northern end of the Intermountain region. Work there has been confined to determining proper rates of stocking with sheep, proper seasons of use, and methods of improving sagebrush range.

Increase productivity of sagebrush range

On many millions of acres of spring-fall range, sagebrush has become so dense that little palatable forage is produced, and much of that which is produced is unavailable. Moreover, in the dense brush there is considerable loss of wool and lambs. Therefore one of the most important steps in spring-fall range improvement is eradication of sagebrush.

Beginning in 1932, work was begun in eastern Fremont County, Idaho, in cooperation with the State of Idaho and the Fremont County Woolgrowers Association, to determine the effects of burning on sagebrush and subsequent range productivity. In 1936, similar studies were begun at the U. S. Sheep Experiment Station. These studies (USDA Farmers' Bulletin 1948, "Sagebrush Burning--Good and Bad,") show that by controlled burning of areas having a reasonably good cover of perennial grasses and weeds, with proper grazing management following burning, grazing capacity can be increased 70 percent or more. On the other hand, uncontrolled burning and unrestricted grazing result in little or no improvement and often in damage to the range and other property.

Methods of removing sagebrush by mechanical means have also been devised. These include wheatland plowing, railing, harrowing with a self-clearing harrow, ripping with a road ripper, and rolling with a spiked roller. Each of these methods results in a reasonably good kill of sagebrush, but none in a total kill. Costs by these methods of eradication are considerably higher than by burning. Results of this work on mechanical eradication have been made available in Research Note No. 10.

No additional research was done on sagebrush eradication during 1945 because of a lack of manpower. Efforts were continued to disseminate the results of past work, with emphasis on adequate fire control and careful management of livestock on burned-over range.

Further research on sagebrush burning is necessary to ascertain in detail the effects of repeated fires on individual species and on the soil, and to observe long- time trends under good management after burning. Two specific questions are: What is the reason for heavy stands of sagebrush following fire in occasional years, even under best possible management? The answer to this question may reveal how such mischances can be avoided. And to what extent and how fast will sagebrush reinvade stands of herbaceous species? In the numerous situations where burning is not possible or where it is not advisable, some mechanical treatment is required. Much more study of methods and equipment is needed to devise effective, economical techniques of mechanical sagebrush removal. There is also need for active program of demonstrating controlled burning and proper management to those who plan to eradicate sagebrush by fire.

During 1946 the station will continue to experiment with different types of eradication equipment. We will observe some of the areas in Clark and Fremont counties that were burned 10 years or more ago. Such observations should show the effect of fire on the vegetation after a considerable period of time and yield some information on the rate of invasion of sagebrush. We will also continue to advocate properly controlled burning and subsequent grazing to range land users and managers.

Evaluate cheatgrass for spring-fall range

Cheatgrass, introduced to the Intermountain region shortly before 1900, is estimated to be the principal species on about 7,000,000 acres of land in the region. In a range survey made on 3,746,436 acres in south-central Idaho, it was found that cheatgrass was the dominant herbaceous species on 1,623,106 acres.

Cheatgrass is now being used extensively by both sheep and cattle growers for spring range. One stockman in southwestern Idaho deliberately spread cheatgrass seed over his sheep range in order to obtain early spring feed. Yet cheatgrass has certain characteristics which make its presence a management problem. After the seeds mature and the plants become dry, it is extremely inflammable. During favorable years it produces an abundance of herbage, but in adverse years it may produce only about one-tenth as much as in good years. Unless rainfall is favorable so that cheatgrass germinates and grows in the fall, it is of little value as fall sheep feed. These and other factors contribute to the problem of evaluating cheatgrass as a permanent type for spring-fall range.

Although a project has never been set up to study the cheatgrass problem on spring-fall range, some knowledge about it has been gained incidentally to other work. A report on the present state of knowledge of this species is being prepared by Pechanec and Hull aimed for publication in the JOURNAL OF FORESTRY. During 1945, too, the rate of development of cheatgrass on burned and unburned areas was compared with that of crested wheatgrass. Clippings were made to compare the production of the two species under burned and unburned conditions. Contacts were made with ranchers, and expressions obtained regarding the use and value of cheatgrass in range livestock operations. Most stockmen think it has a place on spring-fall ranges.

Because cheatgrass has both advantages and disadvantages, depending on where it occurs and from what standpoint it is viewed, considerable study is needed to evaluate cheatgrass adequately. Studies need to be made of the use now being made of cheatgrass ranges by both cattle and sheep and to determine how well cheatgrass is serving as forage. How devastating to the forage supply is fire and how great is the danger of damage to other values? How reliable is cheatgrass production from year to year? How effective is cheatgrass in protecting and preserving soil? How do cheatgrass ranges compare in animal production with native ranges in good condition and with reseeded ranges? If, after these and similar questions are answered, it is decided that cheatgrass is a valuable range type under certain conditions, studies will be needed to determine the best ways of managing cheatgrass range for maximum returns. No detailed study of cheatgrass has been planned for 1946. The more or less incidental inquiry will be continued as to the uses and value of cheatgrass and the effects of fire on the yields and the rate of its growth and development as compared with crested wheatgrass.

Balance stocking with forage supply

One important reason for the depleted condition of spring-fall ranges of the Intermountain region is that far greater demands are made upon the forage than can possibly be met. These ranges have been repeatedly and closely grazed year after year at the same season. Stands of palatable perennial herbaceous species have been reduced, allowing sagebrush and other species of low palatability to spread and occupy the ground.

At the U. S. Sheep Experiment Station pasture studies have been conducted since 1924. Two adjoining pastures, one heavily grazed in spring and in late fall and the other heavily grazed only in late fall, show remarkable differences in species composition and grazing capacity. The fall grazed pasture has little sagebrush and a great abundance of weeds and grass. The pasture grazed heavily both spring and fall is becoming so thick with brush as to make difficult its use by sheep.

Beginning in 1932 three intensities of sheep grazing have been studied and have shown definite trends in vegetation. A manuscript "Grazing spring-fall sheep ranges of southern Idaho" by Pechanec and Stewart, embodies the results of these and more extensive observations on management. The manuscript, which is to be published as a Farmers' Bulletin is ready to be sent to Washington for final editing.

The treatment on the pastures were continued in 1945 but, because of shortage of help and the transfer of Pechanec, few records were obtained.

The study of effects of intensities of stocking as they are being applied at the U. S. Sheep Station should be continued and studied, with a similar objective on spring-fall sheep range in Utah to determine ways of balancing forage supplies with livestock numbers. So far, research has been done mainly on range in good condition. Much further research is needed to determine the rates of stocking necessary to bring deteriorated spring-fall ranges back to their potential productive capacity.

Nothing has been done to study the problem of balancing forage and cattle numbers. It is estimated that 50 percent of the use of spring-fall ranges is made by cattle. Many of these cattle are run yearlong on this type of range. The ranges used by cattle are deteriorated and research is needed to learn how to bring them into productive condition.

During 1946 pasture treatments will be continued at the U. S. Sheep Experiment Station. Special effort will be made to tie down more closely indicators of trend in relation to rate of stocking. The problem of cattle management will be further studied preparatory to outlining a research project.

Determine proper distribution of grazing use

Many ranges are overgrazed and some ranges are used less than they might be because livestock are not distributed uniformly. The chief causes of uneven distribution of grazing are rough topography, lack of or poor distribution of water, and use of the wrong class of stock on a particular range. Topography, of course, cannot be altered to suit grazing needs but it seems likely that management practices can be devised which will do much to relieve the range distribution problem.

No research has been done on spring-fall range to aid in solving the distribution problem. There is, however, a real need for such research. Perhaps the most fruitful attack on this problem involves the distribution of water. How much can improving distribution of water aid in improvement of spring-fall ranges? Where is water development economically feasible? Where it is not feasible, what are the possibilities for hauling stock water? A research project to determine the practicability of water hauling is of first line importance in a spring-fall range improvement program. Other studies might include the effect of salting and riding on distribution and determination of the type of range best suited to uniform use by different classes of livestock.

No work on livestock distribution is planned in 1946.

Determine proper season of use

Although the name "spring-fall" indicates season of use in a broad sense, management of these ranges can be improved by a more detailed breakdown within the spring season. In the migration system of grazing which is followed on the Snake river plains by sheep, it is common practice to graze the same range at the same time each spring. This practice undoubtedly places certain parts of the range at a disadvantage. For it has been found through studies at the U. S. Sheep Experiment Station that clipping at the time bluebunch wheatgrass (Agropyron spicatum) and balsamroot (Balsamorhiza sagittata) are flowering is more detrimental to production the following year than clipping at any other time. Ranges which are grazed at that stage of development each year are obviously handicapped.

The pasture grazing studies at the U. S. Sheep Experiment Station are designed to test effects of rotational and rotational-deferred systems. Results of these grazing treatments are not clear-cut as yet but there is some evidence that grazing under the rotation-deferred system is too severe even when complete rest is granted a pasture one year out of every four.

In 1945 the treatments were continued on the pastures but detailed observations were not made because of wartime curtailment of activity.

The present studies need to be supplemented through comparison--by extensive observation, at least--with the continuous migration system practiced by sheepmen. Also, since many cattle outfits use spring-fall range yearlong, we need to determine whether this is good range practice or whether a shorter or broken season would be better.

During 1946 grazing treatments on the pastures will be continued. Special effort will be made to find indicators of the effects of these treatments which are capable of wide application.

Winter Range

The major winter range areas of the Intermountain region, totalling about 65 million acres, lie in great blocks more or less remote from spring-fall and summer ranges. These areas include eastern and western Utah, central and southern Nevada, southwestern Wyoming, and portions of southwestern Idaho. The vast areas of winter range are characterized by scant, fluctuating precipitation and low forage production. Annual precipitation is usually less than 10 inches. One of their chief characteristics is that livestock depend on snow for a source of water and that a large portion of the winter range cannot be effectively grazed except when snow is available.

About 70 percent of the vegetation, especially that which grows in the broad open valleys and on lower foothills, belongs to the salt desert shrub formation. The remainder consists of sagebrush and pinyon-juniper that grows in the higher valleys and mountains.

Approximately 4 or 5 million sheep and 250,000 cattle graze on the winter ranges of the Intermountain region for a period of 5 to 6 months each year (November to April). This represents about 80 percent of the range sheep and about 20 to 30 percent of the range cattle within the region.

Winter ranges constitute one part of the yearlong grazing operation. An appreciable part of the value of winter range depends on its integration and use with other seasonal ranges so as to provide adequate feed at all seasons of the year.

Chief problems of the winter range are: (1) to determine by inventory the size and condition of the winter range resource; (2) to determine the forage yield; (3) to determine the influence of weather, especially precipitation, on growth, reproduction, and yield of the various plant species; (4) to balance the stocking with the forage supply; (5) to provide for uniform distribution of livestock; (6) to reduce seasonal sheep-migration damage; (7) to establish criteria of proper grazing, or utilization standards; and (8) to determine nutritional value of the various forage species and desirability or need of supplemental feeds such as cottonseed cake, corn, or prepared pellets.

In 1933 a tract of 55,000 acres of typical winter range in western Millard county, Utah was set aside, fenced pastures were constructed, a well was drilled, and headquarters for the Desert Branch Station was established to provide facilities for studying problems of winter range management.

(1) Determine size and condition of the winter range resource

General surveys and exploratory trips over range of the Intermountain region 1930-1936 revealed that forage production was far less than what the ranges were capable of producing. In comparison with protected or lightly grazed range, plant cover on large areas of heavily grazed winter range had been reduced 34 percent and forage yield decreased 62 percent as a result of overgrazing. Results from the exploratory surveys are published in Senate Document No. 199 and in an article entitled "Influence of unrestricted grazing on northern salt desert plant associations in western Utah" by Stewart, Cottam, and Hutchings. JOURNAL OF AGRICULTURAL RESEARCH, volume 60, No. 5, March 1, 1940.

Further evidence of range deterioration is brought out by the fact that heavily grazed ranges, when protected from grazing or grazed only at moderate intensity, recover rapidly. Recovery is as rapid under moderate use as under total protection. On 30 to 40 enclosures established throughout winter ranges of Utah and Nevada and on moderately grazed areas at the Desert Range Branch Station, plant cover, herbage yields, plant vigor, and reproduction show marked increases. Forage production on these areas after 5 to 7 years is 1.5 to 2.5 times greater than on adjacent heavily grazed areas.

Some of the better sites on valley slopes or mountain foothills produce as much as 700 pounds of air-dry herbage per acre while others in the "scabland" or alkali bottoms produce only about 50 pounds. Ranges in good condition often produce two to three times more forage than similar areas in poor condition from overgrazing. These wide fluctuations in production together with differences in quality of forage produced often make some areas 10 to 20 times more productive than others.

In 1945 the enclosures and moderately grazed areas at the Desert Station were maintained. However, data taken at periodic intervals were not obtained in 1945. If funds are available in 1946, data on these areas will be obtained.

(2) Determine forage yields

Records obtained at the Desert Branch Station show that there is a close correlation between forage yield and precipitation received during the preceding 12 to 15 months. From 1938 to 1944 air-dry herbage yields averaged 180 pounds per acre with fluctuations from 75 pounds in 1943 to 264 pounds in 1938.

Much of the herbage growth on winter range is produced by the end of September and the forage supply for the coming winter can be determined from plot yields.

There is a great need for annual forage inventories to obtain yield data on numerous areas throughout the winter range in order to correlate yield with weather and to inform stockmen throughout the region as to the amount and condition of the forage on winter range areas prior to time they take their livestock to them. These inventories after several years' record can effectively be used to forecast production on the basis of precipitation. In years of low production stockmen will then have ample opportunity to adjust their livestock numbers or provide additional feed to augment forage on the winter range.

In 1946 yield and density records will be obtained on the plots within the pastures at the Desert Branch Station. Data obtained will be compiled and analyzed.

(3) Determine influence of weather on growth, reproduction, and yield of plant species

Phenological studies were begun at the Desert Range Branch in 1935. Data were obtained on seven major forage species at fixed plots at weekly intervals throughout the spring and summer growing periods. In addition supplemental data were obtained on other species at irregular intervals and on random sites within the experimental area.

This study should be enlarged to include all the major forage species and expanded to several locations in order to obtain information on growth and growth requirements of the various plants and their relationship to weather and such other environmental factors as soil and associated species. In addition information on such physiological plant processes as plant food production, storage of food reserves, and the relationship of these to grazing, is highly desirable.

In 1946 the limited records on plant growth and the weather records at headquarters will be maintained.

(4) Balance stocking with forage supply

Investigations of the effects of light, moderate, and heavy stocking on vegetation and sheep were started in a series of pastures at the Desert Range Branch in 1935 and data on vegetation and sheep weights have been obtained each year. In addition records on sheep were obtained from two herds, one wintered on moderately grazed areas and the other on heavily grazed range. During 10 years' treatment total plant cover under heavy grazing decreased 20 percent in comparison to that on moderately and lightly grazed areas.

Sheep kept on moderately grazed ranges throughout the winter remained in 8 pounds better flesh, produced 1 pound per head more wool, produced 7 to 10 percent more lambs, and suffered 5 to 11 percent less death loss than those on heavily grazed range.

In 1945 a manuscript on "Management of winter ranges in the Intermountain region" by Hutchings and Stewart was prepared, reviewed, and revised and will be submitted to Washington for Board of Review comments early in 1946.

Additional experimental work is needed on other subtypes, particularly the black sagebrush on the foothills, to evaluate the effects of grazing on these subtypes and to determine how information obtained from the pastures in shadscale-winterfat types can be extended to other areas. To date the studies of balancing livestock and forage have been confined to sheep. Later studies should be expanded to evaluate cattle grazing.

In 1946 the routine work in the intensity study with sheep will be continued and data obtained on forage production and density as influenced by intensity of use. The manuscript on the studies to date will be submitted to Washington for review, later revised and submitted for publication.

(5) Provide uniform distribution of livestock

Livestock on winter ranges are often unequally distributed, especially during dry periods when snow is scarce. At these periods livestock are confined to localized areas around watering places or adjacent to snow, and are trailed to and from snow and water. In the early spring sheep are concentrated around strategic shearing corrals where sometimes 20 to 30 thousand are sheared at a single corral.

Water is one of the most critical items needed on winter ranges to insure uniform use and distribution. Watering places and snow areas are foci of concentration where overgrazing and trampling damage is severe. New watering places are quickly transformed into new points of concentration.

Experimental studies to determine the amount of water required by livestock and the feasibility of hauling water to the animals on winter range were begun at the Desert Range Branch in 1936. Hauling water proved beneficial and economically feasible. Long trails to water or snow were eliminated and trampling injury was reduced. Livestock were kept on fresh feed, troughs were frequently moved to new locations to control grazing and provide for uniform utilization. A preliminary report on water hauling has been prepared and will be published in one of the forthcoming issues of the NATIONAL WOOL GROWER.

Studies are needed to determine the number and frequency of watering places, number of animals, and number of times they should use a given watering place; effects of trailing to and from water on both the range and the animals. Studies are also needed to determine the effects of shearing corrals on both range and sheep.

Plans for 1946 do not include studies on livestock distribution, except incidentally to other work being conducted at the Desert Station.

(6) Reduce damage from seasonal sheep and cattle migration

One of the major problems connected with use of winter range is the long migrations twice each year, to the winter ranges in the fall, and to lambing and summer ranges in the spring. These migrations, often of 100 to 200 miles, over rugged, dry country where widely separated and strategic watering places and shearing corrals form foci of congestion, trampling, and overgrazing; deplete the narrow driveways; and lower the vitality of the sheep. Migration hazards of storm, insufficient forage, insufficient water, and areas of poisonous plants, cause heavy death losses especially in the spring when ewes are poor and heavy with lamb. Almost one-half the winter losses occur along migration routes. Studies on better trailing methods, trucking, feeding, etc. are needed to reduce trailing losses and damage.

A few sheep are trailed to railheads and shipped and a very few--usually old ewes and rams--are trucked. The trailing problem has been outlined by H. R. Hockmuth, Earl R. Franklin, and Marion Clawson in an article "Sheep migration in the Intermountain region," U. S. Department of Agriculture Circular No. 624. Solution to migration difficulties will be beneficial to range and livestock. This problem should be considered for future study.

(7) Establish criteria of proper grazing

Criteria of proper grazing in terms of utilization have been obtained from intensity studies in the pastures. Under proper utilization enough current growth of the various forage species must be left to keep them productive and vigorous. Blanket stocking factors cannot be established because of variations in forage production on different ranges. Grazing capacity figures obtained from the desert studies cannot be applied directly to the entire winter range. Levels of use based on stubble heights which appear to permit the plants to remain vigorous have been established for the major forage species. It may be possible to apply minimum stubble height standards to other range areas with some modification.

On properly grazed ranges in full production, plant cover is good, the better forage species are thrifty and productive, many young plants of the better species are present, and soil is essentially stable except during torrential storms.

In 1945 utilization records were taken and compiled. Previous data are presented in the Desert Range manuscript.

Additional information is needed to include other factors than utilization in criteria of proper grazing. Also winter ranges need to be classified as to type and condition and grazing criteria established and described for each type and condition class. This would aid managers and stockmen to evaluate their range and provide them with standards of use.

In 1946 a paper will be prepared for publication on the production, grazing capacity, and description of the various forage types in different classes of range condition.

(8) Determine nutritional value of forage species and need of supplemental feeds

Winter ranges are grazed during the period when most of the forage species are dormant and when the nutritional value of many of the forage plants, especially herbs and grasses, is low. Maintenance of livestock on such ranges, where forage is sparse and weather conditions severe, is difficult. On winter ranges where animals receive ample quantity of forage they frequently lose weight and become poor, especially when grasses and shrubs are exceptionally dry. Preliminary studies by the Utah State Agricultural College indicate that winter range forages are low in protein and that protein supplemental feed may be desirable. A study is needed to make chemical and digestibility analysis of the major species at intervals throughout the winter. Also studies are needed to determine the value of various supplemental feeds such as cottonseed cake, corn, pellets, etc. as to period to feed, amount to feed, effect on sheep, and effect on range.

Plans for 1946 do not include studies on chemical analysis of forage plants or supplemental feeds.

Utilization Standards

The problem

How much of the forage growing naturally on western ranges can livestock use without destroying the soil and its plant cover? This, broadly, is what the administrator of these range lands must know.

He does know that if stock use all the forage year after year, the better plants disappear and the soil soon washes or blows away. On the other hand, he knows that the users of his range are pressed for feed and usually need all they can get. How much can he allow them to have and still preserve the resource? The administrator is on the horns of a dilemma.

To help get him off, this station has under the Utilization Standards project attempted to answer specific questions such as these: What are the means of measuring utilization? What are the responses of individual plants to herbage removal? What are the effects of various range sites and conditions on the physiological functions of cropped plants? What are the methods and dimensions that can be used in evaluating range conditions and trends? And what are the relationships of these conditions and trends to past, present, and future utilization of the forage?

Some of these questions concentrate on individual plants or plant species. Most require consideration of the range as a complex plant community, including the individual plants. Knowledge of the plant community and its environment provides the framework into which studies of individual plants or plant species can be fitted.

Past work

Various methods of measuring utilization have been developed at several forest and range experiment stations. Study of the stubble height method by Clark showed that the amount of stubble left on grazed plants was not a good index to the percentages of the volume taken, since the growth form of the plants on central Utah's summer ranges was too variable. The weight estimate by plot method of Pechanec and Pickford was considered better.

Responses of individual plants to herbage removal have had considerable attention. McCarty and Price made physiological studies of the march of carbohydrates in many widely distributed species. Clark's study of spring grazing of wild hay meadows near Big Piney, Wyoming showed that the total amount of forage derived as hay and grazing from spring-grazed meadows was greater than that from hay cut alone. Also, the protein content of hay from grazed meadows was greater than that from ungrazed ones. An exploratory study on the relation of plant vigor to utilization was set up on the Wasatch Plateau in 1938.

The community aspects of the problem have received less attention. However, Sampson's early determinations of percentages of allowable use on isolated plants soon had to be modified. Forsling and Storm established that there must be a decrease in proper use factors of palatable species when these occur thinly scattered in a stand of an unpalatable plant such as oakbrush. That is, allowable use is not a constant value for a species regardless of where or how it grows, in spite of the fact we have and use tables of "proper use." The palatable species, those considered "key," must be selected in relation to the structure of the plant community.

Sampson's early work on plant succession in relation to range management was the first consideration of plant communities as they determine, and are determined by, range utilization. It was the first work on condition and trend. Preliminary attention by Clark under the Utilization Standards project to range condition and trend resulted in the Intermountain Range Utilization Handbook in 1939. As noted, the main effort of the project was then turned toward the study of individual plant responses.

1945 work

During the year Clark left the project. Little field work could be done because of lack of manpower.

Analysis of the plant vigor in relation to grazing study shows that the smaller plants tend to have a greater proportion of their herbage removed than larger plants. That is, on the percentage basis commonly used for measuring utilization, small plants were the more heavily utilized. This raises the question of the validity of percentage use as a measure of utilization when this must be calculated on a variable and shifting base. Are percentages of what we think the plant originally looked like when grazing started, plus any growth, the best measure of utilization?

Preliminary analysis of the data on plant vigor in relation to site factors and utilization corroborated the evidence on greater use of small plants, indicated that plants of steeper slopes with shallower soils are more heavily utilized, and quite unexpectedly showed that mortality among grazed plants was so high that most of the staked plants, on which records were being kept, died.

1946 work

Utilization of the complex plant communities forming the range will be the focus of study. Laboratory and field studies of the utilization of individual plants or species must be fitted into this complex.

We need to go back to the beginning. Just what is range utilization? It consists of the cropping of plants by livestock and the concomitant changes in the plant cover and its environment. Cropping is selective as to species, times, and places. Some plants in some places are weakened by it. Therefore others are favored. The results are range trends, changes, leading to certain range conditions.

Community studies are basic to understanding condition and trend which is the outstanding current problem in this region. The plant community and its environment is the entity which is in a certain condition and whose changes are trends.

These reemphasized studies of plant communities in relation to range condition and trend are needed to provide the basic data for Administration's tools in managing the range, "key species" and "key areas." To use key species we need to know the plant's place in the community as well as its individual resistance to cropping. Key areas are simply those areas likely to show critical condition or trend.

All the plant types on the western range need utilization study. The Utilization Standards project, however, has only very limited funds and personnel; and therefore, its effort must be concentrated to be effective.

The aspen type is advantageous for detailed community studies leading to conclusions on condition and trend. It is a widespread type throughout western United States. Although little ecological work has been carried to completion in the type, a great deal of miscellaneous information has been accumulated. Not least are the data from the Utilization Standards project on the relation of site and utilization to plant vigor. Also, scattered and generally neglected study plots were established by Administration on the type three decades ago. Aspen stands promise great returns in increasing grazing capacity. Whether this improvement should be by allowing natural secondary plant succession to take its course or by artificially reseeding is a question not answerable without knowing both what natural plant successions there are in the type as well as the practicality of reseeding. There is information on the latter; there is not on the former. And finally, if we decide natural succession will let the range recover, how long will it take in relation to the present very variable herbaceous covers which differ both by subtypes and by degrees of condition within subtypes? If we decide on reseeding, how long will the reseeded species persist in the face of competition with native species?

Three main problems can be separated in a consideration of the aspen type. First, what is the type and of what subtypes does it consist? Costello (Conference on methods and techniques relating to national forest range and wildlife management, Denver, 1944, IIIC, p. 6) mentions eight subtypes commonly found in range type 10, aspen, presumably in R-2. Many of these and several others may be found in R-4. After we have differentiated the subtypes, we can evaluate the differences between them for management. Certainly potentialities of the subtypes are different. Key species are different. And management differs according to what is being managed.

Second, what are the changes in the type? We suppose generally that aspen stands are temporary. What does this mean in terms of years? And if an aspen stand is economically advantageous, how can we thwart natural plant succession and perpetuate the stand? Finally, what are the mutual relations of changes in the type with the neighboring types, such as lodgepole pine, spruce-fir, alpine meadow, mountain brush of several kinds, sagebrush, and grassland?

Third, what are the changes in the subtypes, classified according to ground vegetation, under the aspen overstory? These are the shorter term changes which directly determine range condition and affect grazing capacity. They are of immediate, practical significance.

Thus, after defining the type, the aspen study will be essentially one of plant succession.

Two jobs will be carried on the first season in line with the above objectives: (1) Recovery of old administrative study plots. Some of these have been established for 30 years. It is difficult to overemphasize their importance. They can give exact information on plant succession which can be obtained in no other way. Changes in the plots will be noted as they are recovered, and these will be correlated with the broader changes as noted below.

(2) Extensive observations throughout Utah, at least, to determine the limits and character of the type and subtypes. Also, to determine potentialities in productivity, as well as to assess successional changes, natural or long-protected areas will have to be located and studied.

BIG GAME

Within the Intermountain region it is estimated there are 400,000 deer and 50,000 elk. Of these approximately 320,000 deer and 40,000 elk summer on the national forests of the region and a smaller number remain there throughout the winter. These big game animals furnish recreation in the form of hunting for over 160,000 hunters each year. The pleasures of observation and hunting are enjoyed by people outside the region as well as by local individuals. These game animals form an important economic and social asset to this region.

Big game animals have increased remarkably in the last 25 years. Since 1921 estimated deer numbers within the Intermountain region increased from 78,900 to 400,000. This great increase resulted through protection, establishment of refuges and closed seasons. The increase does not necessarily mean that there are too many deer and elk within the region, for, because of unequal distribution, the animals are congested in some areas while others may be too thinly populated.

In many of the congested localities large areas of national forest and foothill ranges are heavily grazed and depleted. Browse species such as curlleaf mountain mahogany, true mountain mahogany, Stansbury cliffrose, and antelope bitterbrush are injured by overutilization and in some areas, especially on foothill ranges where deer congregate in winter, juniper and sagebrush are hedged. On summer ranges where deer are too numerous aspen reproduction is injured and killed and watersheds are damaged. During the winter especially when snowfall is deep, deer congregate on the lower parts of national forests and on adjacent private grazing lands where shortage of range and forage are critical. In these congested areas deer often invade nearby ranches and eat the hay and forage needed for livestock. Sometimes shortage of feed is so acute that deer die from starvation.

In many cases the critical problem areas on the national forest ranges are used jointly by livestock and big game. During the last 20 years livestock have been cut to provide protection while deer and elk numbers have skyrocketed. Livestock permittees resent reductions in cattle or sheep when game is allowed to increase uncontrollably without management.

In 1939-42 the Intermountain Forest and Range Experiment Station cooperated with Region 4, Utah State Game Commission, and Utah State Agricultural College in preliminary deer range studies. In 1940 the U. S. Forest Service constructed a 741-acre pasture near Fillmore, Utah in Millard County. The principal plant cover consisted of gambel oak, big sagebrush, and Utah juniper, with a good variety of deer forage species such as antelope bitterbrush, curlleaf mountain mahogany, Stansbury cliffrose, and true mountain mahogany. Studies on food habits, grazing capacity, forage preference, and utilization were begun. Unfortunately a range fire in September 1942 burned the entire area and destroyed the fence. Progress reports on the studies have been prepared.

During the last several years the Forest Service and the State Game Commissions have been able to make some progress in reducing game numbers on some of the most critical areas. However, there is little basic information available on deer and elk as to forage requirements, species eaten, or relationship to livestock grazing, on which to base game management practices. Livestock associations, sportsmen's organizations, state game officials, and Forest Service officers all agree that there is urgent need for research on game and game management particularly with respect to utilization of forage by deer and elk and competition between big game and livestock. Sound game management cannot be accomplished unless it is coordinated with other watershed resources and properly integrated with such uses. This requires detailed and thorough information that can only be obtained by careful research.

The Intermountain Station is conducting no big game studies at the present time. However, it is hoped that cooperative studies can be resumed in the near future.

RANGE RESEEDING RESEARCH

The extreme difficulty of reducing grazing use on national forests to the level of range forage supply has greatly sharpened during 1945 our comprehension of the need for reseeding. Awareness of deterioration in plant cover and range forage production on summer and spring-fall ranges has welled up around us and forced itself into the foreground. The urgent need of improving plant cover arises not only from the deficiency of range forage but also from the danger of flood run-off and soil erosion on critical watershed lands. That need is nearly always greatest where deterioration of vegetation has reached the most advanced stage. Recovery of the vegetation under reduced grazing is likely to be slow, requiring several years to build up the plant cover to a good forage yield or to an efficient protection against high run-off and soil erosion. More and more it is recognized that range reseeding is the means that must be used for correcting really bad conditions. Reseeding on favorable sites gives a rapid response and provides a plant stand that is effective as a watershed cover. With 5 million acres of abandoned farm land in the region and another 8 to 10 million acres with badly deteriorated plant cover, range reseeding is bound to be a major factor in management of range and watershed lands.

Problems to Solve

The broad reseeding problems of providing at low cost more forage and more effective plant cover on watershed lands, when broken down according to the specific problems to be solved, fall into six categories, as follows:

1. Site classification. It is urgently necessary to determine in what climatic zones and on what sites reseeding is justified. The degree of injury to vegetation that warrants reseeding demands the most careful

study. Since reseeding gives greater returns when done on superior sites, research needs to provide information not now available on how to classify sites as to the results that may be expected from reseeding.

2. Suitable species. Determination of the most suitable species of forage plants, or of strains within species when they are isolated, for each elevational zone constitutes a highly important job, which is as yet far from complete. Recommended species or strains must also be proved to be suitable in unfavorable years as well as in favorable ones.

3. Seedbed preparation - methods of seeding. Effective and comparatively inexpensive methods must be found of removing the competition caused by brush, cheatgrass, or weeds; of preparing seedbeds and of getting seeds properly planted. Great need also exists of determining at what season of the year to plant.

4. Machinery. Adaptation of existing machinery and the development of new and stronger machinery for eradication of brush and getting seed into the ground are required in order to increase the chances of success and to decrease reseeding costs.

5. Management of reseeded lands. Need for information on how and when to graze reseeded range land is unusually great, because of the rapidly increasing acreage for which there is now little guiding information.

6. Adapting plot findings to range reseeding. Demonstration areas and demonstration methods are indispensable to researchers in determining how to apply plot findings to large-scale planting, in reducing costs of operation, in teaching to others the best methods to apply, and in conveying to them an adequate idea of what to expect from reseeding.

Research Findings

Where to Reseed

The sagebrush zone has been rather thoroughly explored as an area in which to reseed. It has been found that wherever a good vigorous stand of sagebrush occurs, both precipitation and soil conditions are favorable for reseeding. Deep soils of intermediate texture and moderately porous structure are most favorable. Precipitation from about 9 inches and up has been found to support good stands of suitable grasses. The mountain brush and aspen zones have been found to be climatically even more favorable than the sagebrush zone. Only the fairly deep, well-preserved soils in the mountain brush zone have been tested as yet. Research in mountainous areas is just getting well under way, because during the first years, research in reseeding was concentrated in the sagebrush zone. It is known that the best soils in the high mountains are favorable. The salt-desert zone, used largely for winter range, receives precipitation generally below 8 inches. Many of the soils are shallow, excessively gravelly or sandy, low in organic matter, or impregnated with soil salts. Only a scanty success has resulted from the exploratory planting so far done.

So long as vast areas of abandoned farm land or land with natural vegetation badly deteriorated remain to be seeded, the reseeding of areas with poor cover which will recuperate under better care cannot be justified. It seems likely however that after "critical" areas are restored, reseeding will be profitable on areas with fair plant cover, for many indications suggest that in certain cases at least, the yields from reseeded stands are higher than from ordinary native range. It is recommended for the present that only areas on which grazing management cannot restore the native cover in 3 to 5 years be reseeded. Such ranges are found in great tracts of sagebrush as on the Snake River plains of Idaho and on foothill ranges in Utah and Nevada where less than 100 pounds of grass per acre is produced. Heavy stands of brush prevent the quick increase of grass when grazing is greatly reduced. Large areas of mountain brush in Utah and Idaho are also in a similar condition. In some cases the total cover is reduced to half or only a third of that on good native range. In still other cases, weedy annuals such as tarweed (Madia glomerata), poverty sumpweed (Iva axillaris), and whitetop (Cardaria draba) have replaced the native perennials. Russianthistle areas are suitable for seeding without further preparation.

Determining what sites justify reseeding and how to classify them according to the results that may be expected are so important that a special study of it is being organized. Robertson, who is being succeeded in Nevada by Hurd who is just back from the Navy, will spend most of his time in studying this problem.

What to seed.

Of more than 330 species tested only two are known to be widely adapted on sagebrush lands of the valleys and low foothills. No doubt exists of the suitability of crested wheatgrass (Agropyron cristatum) for most conditions. Four new species, intermediate wheatgrass (A. intermedium), stiffhair wheatgrass (A. tricophorum), tall wheatgrass (A. elongatum), and Russian wildrye (Elymus junceus) have all done well for 3 or 4 years in the valley and foothill sagebrush areas. These new wheatgrasses (from Asia) have outyielded crested wheatgrass in one 3-year trial in Nevada, and have shown up well in Utah and Idaho. As yet they cannot be recommended because seed is not available in quantity, nor have they been widely tested either in area or in time. They are so promising, however, as to demand a thorough test. Our own seed multiplication plantings will furnish a quantity of seed that will permit them to be planted in enough research plots to provide a comprehensive test.

In the mountainous zones where cooler and wetter weather prevails, smooth and mountain bromes (Bromus inermis and B. carinatus), orchardgrass (Dactylis glomerata), slender wheatgrass (A. trachycaulum), tall oatgrass (Arrhenatherum elatius), and timothy (Phleum pratense) have all done well. In damper places Kentucky bluegrass (Poa pratensis) often succeeds. About a dozen others do well but are as yet too new to have seed available in quantity. Crested wheatgrass is unsatisfactory in the mountains above about 7,500 feet in central Utah and above 6,500 feet in central Idaho.

Some suitable species such as smooth and mountain brome, slender and western wheatgrasses, and crested wheatgrass, give widely different responses according to the strains of the species that are seeded. For example at the Majors Flat nursery in Ephraim Canyon, six strains of smooth brome yielded in the third growing season, 1,480, 1,484, 2,392, 2,804, 4,413, and 6,971 pounds of air-dry forage per acre. Five western wheatgrass strains yielded from 1,196 to 4,496 pounds per acre, and four strains of crested wheatgrass from 3,093 to 6,671 pounds. Some strains of mountain brome have proved to be shorter lived than ordinary stock, and some much more leafy. It appears likely that certain strains are more resistant to close clipping than are others. This quality might help greatly in grazing resistance, although the fact is not as yet established.

What to seed on salt-desert lands used as winter range has not been determined. Indian ricegrass (Oryzopsis hymenoides) grows in the more favorable situations and a few seedings of crested wheatgrass have succeeded on some of the best sites but failed on the poorer ones.

In 1946 observations of stand and yield will be made and data taken from all previously planted species tests that have reached a sufficient stage of development. Added tests of species and strains will be made in the mountainous areas. In the salt-desert zone new species must be found and promising ones tested on a thorough-going scale.

How to seed

Once the area to be reseeded is decided on, the manner of preparing it for planting must be considered. Research has found that competition from the old cover must be removed or at least greatly reduced to permit young grass plants to take hold. For example, the necessity of reducing competition by removing sagebrush is shown by the fact that Nevada seedings in undisturbed sagebrush, in sagebrush partly removed, and completely removed gave yields of 757, 1,191, and 3,216 pounds of air-dry herbage per acre. In Idaho air-dry yields on railed land with 55 percent removal averaged 252 pounds per acre (cost $2.02 an acre) whereas the corresponding figure for 98 percent removal by burning after railing gave 1,274 pounds per acre (cost $2.63 an acre).

Experimental records show that almost complete removal of sagebrush resulted from burning, both accidental and planned, about 75 to 90 percent by wheatland plowing, and 50 to 70 percent by railing. Mere scorching of the twigs usually killed the plants. Cheatgrass stands in early spring the year after fires that occurred before August 15 were reduced to less than 50 plants of cheatgrass per square foot as compared with 400 to 700 after October and November burns. The average on unburned areas was 695. Stands of 2-year-old crested wheatgrass were successful when seeded in the fall after June, July, and August burns and were more than twice as good as those seeded after October and November burns. Time of disking and plowing had similar effects in reducing stands of cheatgrass but much less beneficial effects in producing stands of crested wheatgrass.

Since loose seedbeds are unfavorable to obtaining good stands of reseeded species, plowed areas should be allowed to settle before being planted. On the average the best stands and the highest yields of reseeded forage have been obtained by drilling in the fall directly on sagebrush stubble that had been burned in the summer ahead of reseeding. This is likewise true of mountain brush lands, although the greater precipitation at higher elevation tends to offset the detrimental effects of loose seedbeds. Good stands are usually obtained after removal of brush with the wheatland plow, either by drilling the seed later on or by broadcasting at the time of plowing, provided the broadcast seed is amply covered by soil sloughing but not buried too deeply. A laboratory test where all other conditions were highly favorable gave no emergence of crested wheatgrass from 3-inch depth and only about 15 percent from 2 inches. The seed germinated more than 90 percent.

Plot plantings on tarweed flats on the Manti Forest show conclusively that destruction of tarweed plants before they seed is necessary in order to establish good stands of reseeded grasses. Plowing in the late summer followed by drilling gave fair germination stands that were crowded out by 100 to 400 tarweed plants per square foot. Removal of tarweed by the duckfoot cultivator at 2-inch depth and seeding during May 1943 gave full stands that were still good at the end of 1945, were 36 inches in height and yielded more than 2,000 pounds of air-dry forage, or around 4 cow-months of feed per acre. This finding apparently applies to all high-elevation "flats" occupied by tarweed. It is thought also to apply to annual weed types generally.

Evidence collected in 1945 bears out the previous findings that fall seeding is best except where summer rains are abundant; that covering the seed in some manner is needed; that disk drills are superior to other types; and that rough land responds more quickly to ample rates of seed sowing, i.e. 7 to 8 pounds per acre in the valleys and foothills and 14 to 16 in the aspen zone.

Studies on methods of seeding will be emphasized during 1946 in the mountain brush, aspen and alpine zones where more information is needed. Tests will begin in the salt-desert zone on an exploratory basis and be strengthened subsequently when promising "leads" are found.

Adjustments in machinery or method

During 1945 several adjustments in machinery or in its operation were made that gave increased efficiency. The disks of wheatland plows were found to kill sagebrush more effectively when set at an angle of 40 to 45 degrees. Aligning the plow wheels with the tractor tracks was found to reduce the draft. A hitch was rigged up which permitted 60 h.p. tractors being used on the Nevada forests to pull two plows instead of one. A somewhat larger plow hitch lessened the breakage in the hitching device that occurs when crawler tractors are used for power. Rail assemblies for railing down sagebrush were considerably improved by being so built as to move somewhat more freely in the joints. A blade attached to the front face of one of the rails increased its cutting effectiveness. The heavy A-rail in right and left halves developed by Caribou Forest officials was more suited to rough land and removed somewhat more sagebrush than the previously used solid A-rails.

Flynn of the Equipment Laboratory in Portland and Pechanec of Pacific Northwest Station toured Region 4 during the summer and had a good look at the weak points of present plows, drills, rail drags, etc., and discussed them with forest officials. Flynn made some suggestions and promised more when he could work out a few ideas. Through cooperation with the Equipment Laboratory a "stump-jump" plow has been ordered from Australia to be tried first at Intermountain. A palmetto brush cutter purchased by Region 4 and tried in Nevada was found to cut sagebrush on land free from rocks, but to dull badly on rocky land. This machine was costly to purchase and to operate on account of being narrow and dulling quickly. It is not recommended.

A motorized seeder mounted on tractors was shown to be highly serviceable, and to lessen costs considerably when broadcasting is done at the time of plowing. Fluted feeds with gate adjustments caused less trouble than force feeds. A heavy shield on the chain drive of the seeder reduced breakage to a marked degree.

Airplane seeding was tried in October 1945 in aspen and oakbrush in Ephraim Canyon, Utah at elevations ranging from 7,500 to 8,500 feet. With a plane loaned to us without rental by the Bureau of Entomology and Plant Quarantine we seeded 1,300 acres in 17-1/2 hours of flying time. It took 8 days, however, to do the flying as the elevation was near the absolute ceiling of the plane and the pilot could not fly except when the air was still. Approximately $2,100 worth of mixed seed was distributed at the rate of about 12 pounds per acre at a cost of 23 cents an acre, including pilot and his per diem, oil, gas, and all operating costs except mixing and loading seed which was done by Forest Service personnel. Checking on the ground, also by Forest Service personnel, showed that the seeds were distributed at a higher rate in the middle of the seed swath. Some misses between seed swaths and some overlapping occurred. Notwithstanding the difficulties encountered it is thought that this area covered with brush and trees, and uneven in terrain could not have been sown as uniformly by hand--by seeding machinery it would have been impossible. It is estimated it would have taken more than 250 man-days or more to have seeded the area by hand at a cost of about $2.00 an acre.

Previous tests had shown that broadcasting on the surface of the ground had a good chance of success on aspen and mountain brush ranges when seeded before or during leaf fall. In all cases where there is no leaf fall the chances of success are extremely small--almost nil in fact except with bulbous bluegrass (Poa bulbosa).

The study of adjustments in machinery will continue during 1946 and as long as it yields improvements that seem worth trying. Data on stands established from airplane seeding will be recorded and studied. It is desirable also to find an airplane so powered that it is safe to use in broken mountainous areas at elevations up to 10,000 feet. It is important also to find or make a device that will improve the distribution of seed in the swath. This item will be studied further in 1946, and later if necessary.

Grazing reseeded lands

Experimental grazing at Benmore in 100-acre pastures on a 5-year-old stand of crested wheatgrass (cooperative with Soil Conservation Service, Bureau of Plant Industry, and Utah Agricultural Experiment Station) produced an average gain on 425 head of stock cattle of 2.68 pounds per day from April 28 to July 2 and 0.23 pound a day from October 15 to December 5. Similar cattle on native range gained 1.71 pounds in spring and lost 0.48 pound a day in fall. The native range had only about half its normal intensity of grazing as the 425 cattle in the pastures lessened the use on outside native range by that amount. The stocking rate on adjacent sagebrush range is regularly 10 acres per cow-month; the pastures were grazed at the rate of 1-1/2 acres per cow-month. In addition about 30 percent of the forage in the pastures was left unused for plant protection.

Crested wheatgrass was ready to be grazed more than 20 days ahead of cheatgrass which grew in the same pastures where the stand of crested wheatgrass was thin. By the end of the spring grazing period crested wheatgrass was utilized 59 percent and cheatgrass 3.5 percent. Crested wheatgrass is rapidly filling in the misses and crowding out the cheatgrass where the miss is not larger than a few square rods. Either late or moderate grazing allowed the production of dry flower stalks of crested wheatgrass that were not eaten. Only under heavy early use was production of dry, unpalatable stalks avoided.

At Ephraim, Utah crested wheatgrass and rye produced gains of 17.2 and 14.2 pounds in comparison with 5.1 pounds per ewe kept in corrals and fed 5 pounds of alfalfa hay and one-half pound of barley a day per head. Rye pasture had a grazing capacity of 7.7 sheep-months per acre at a cost of 11 to 13 cents per sheep-month and crested wheatgrass 6.6 sheep-months per acre at a cost of about 8 cents. At the Ruby Station near Wells, Nevada 14 acres of crested wheatgrass furnished 12.8 cow-months under moderate spring and fall grazing. At Dubois, Idaho two 1/2-acre pastures were moderately grazed at the rate of 120 sheep-days or four-fifths a.u.m. per acre. Crested wheatgrass was ready for grazing a week or more ahead of native range.

The study at Benmore will be strengthened in 1946 to make the best use of the pastures and to learn as much as possible about how best to graze reseeded range lands. Data will be taken again at Ephraim and other observations will be made wherever possible. Grazing capacity of several large demonstration areas will be obtained in cooperation with administration, and every effort made to get the areas grazed properly. Ruby Valley cooperative area and the Dusterberg Ridge will be grazed lightly in the fall of 1946 and regularly after that.

Demonstration plantings and methods

Four demonstration areas were used to good advantage in 1945 for such research purposes as testing on a large scale methods of seeding derived from plot studies; studying and trying adjustments in machinery, getting estimates of cost, and estimates of grazing capacity. An area of 45 acres on Dusterberg Ridge in Ephraim Canyon seeded in November 1944 on an area of mountain brush that had been burned off for that purpose showed burning to be highly effective for removing competition and a feasible method of clearing brush-covered land. By the end of the first year this area was yielding more than three times as much forage as adjacent and similar unseeded range. Grasses were growing more vigorously on the burned area than on adjacent plots previously seeded after wheatland plowing, where some sagebrush remained.

At Ruby Valley, Nevada a planting of 800 acres cooperative with Humboldt Forest, the Grazing Service, and three stockmen had an unusually good stand, demonstrating for Nevada the great possibilities of seeding deteriorated sagebrush range. Many observations on adjustments of machinery and the effects of planting methods were made here. A considerable advantage of plowing as compared with railing showed up. The possibility of getting good stands of grass by broadcasting immediately behind the plow and allowing soil sloughing to cover the seed was evident. Forage production by the end of 1945 was fully five times as great as on adjacent and similar unseeded range.

Two other areas of about 400 acres each were prepared by wheatland plowing and seeded, one by the Toiyabe Forest near Paradise Valley, Nevada and the other by the Grazing Service near Sublett, Idaho. Research personnel cooperated by furnishing advice and some general supervision together with suggestions on the handling of machinery and seed.

Our principal contribution was to get the jobs done according to the best research information; our principal gain will be to observe the results of seeding, to get data from plots set out along with the administrative plantings, and to learn what is the cost and the grazing capacity of each area when stands are established and grazed. An opportunity will also be afforded to make available our best information on how to graze.

Large acreages have been found to be much more valuable than small plots in encouraging stockmen to seed for themselves. Large areas seem to impress them.

Conferences and "show-me" trips have made important contributions during 1945.

A principal event in reseeding research in the Intermountain region for 1945 was a conference of directors, reseeding technicians, and WO personnel at the Great Basin Branch July 2-7. The purpose was to enable other stations and regions with new reseeding programs to profit as much as possible from work already done at the Intermountain. Our method of attack, work plans, and progress were outlined and a visit of a day made to the various plots to illustrate methods of attack, procedures, and results. Discussions followed from which Intermountain profited materially. All stations were provided with a summary of work plans and a full list of species, showing the degree of success each had attained in four elevational zones: valley, foothill, aspen, and alpine.

In August 1945, a visiting field day was held at the Great Basin Branch Station devoted to range reseeding and range and watershed conditions. A group of 66 interested men were in attendance including the director and assistant director of Utah Agricultural Extension Service, eight county agents, and several local leaders in the Grazing Service, Indian Service, and Soil Conservation Service. Reseeded plots and areas were in good condition to be viewed at the time. A series of requests to present our findings at county and educational group meetings in early 1946 grew out of the interest aroused at field day. More than 500 persons at five meetings have seen slides and/or heard the report of our research, about 200 at the Utah Cattle Growers Annual Meeting.

During September we had a visiting forester from Peru interested in reseeding, who spent 4 days with us. In addition, about 20 technicians have visited the reseeding plots individually or in small groups, among whom were the president of the Utah Agricultural College, director of Utah Experiment Station, and the extension agronomist.

During 1945 Robertson and Pearse published in NORTHWEST SCIENCE "Artificial Reseeding and the Closed Community," pages 58-66, and Pechanec in AMERICAN HEREFORD JOURNAL "This Stockman Finds a Good Investment." As part of a symposium for British Empire and North America on "The Establishment and Early Management of Sown Pastures" Stewart published in Bulletin 34 of the Imperial Bureau of Pastures and Forage Crops an article on pasture and range reseeding entitled "United States of America: Intermountain Region and South Pacific Coast," pages 180-195, illus. Figs. 68-83. Three short articles by the reseeding staff also appeared in THE NATIONAL WOOL GROWER. Two short mimeographed articles appeared as part of Forest Service "Conservation Panel" at Utah Educational Association and two long papers in Proceedings of the Denver Joint Working Conference on Grazing.

WATERSHED MANAGEMENT AND PROTECTION

Destructive floods, inadequate water supplies and harmful siltation are a constant threat to the million people who live in the semi-arid valleys of the Intermountain region. All of these problems stem from irregular run-off and erosion on the mountainous watershed lands that flank the developed valleys. Because run-off and erosion are materially affected by use of the land resources as well as by the interaction of highly variable factors of climate, topography, plant cover, and soil, the control of floods, the improvement of water yields and the stabilization of mountain soils pose many difficult research problems in watershed management and protection.

During 1945, further progress was made toward the solution of these watershed problems through a continuation of stream flow and soil stabilization studies at the Wasatch and Great Basin Work Centers, supplementary investigations of local flood problems, analysis and publication of results and extension of technical assistance.

Stream Flow

Stream flow in this region is characterized by sustained high discharges during the snow melt period in spring when there is relatively low demand for water and by low and inadequate discharges during the summer and fall when there is high demand for water, especially for irrigation purposes. An important exception to this general regimen of run-off is the occurrence of violent discharges of from a few minutes to a few hours duration which often originate on relatively small areas during high intensity summer storms. These summer floods not only cause direct damage by inundation but also aggravate the low summer water supply problem by damaging reservoirs, diversions and canal systems.

These stream flow characteristics pose the problem of determining ways and means of preventing the destructive summer floods and of increasing the useful yield of stream flow during the summer and fall seasons. The control of floods is being sought through the development of watershed improvement measures which will prevent run-off and erosion. Increased yields of useful summer water supplies are being sought through studies aimed at developing methods of reducing interception, evaporation and transpiration losses and of storing surplus winter and spring run-off in underground basins.

Progress on Flood Control Problems

The occurrence of record-breaking summer storms in Utah last summer provided an excellent opportunity for testing the effectiveness of the flood control work on the Davis County watersheds. Full advantage also was taken to study local floods and to assist in the development of watershed improvement programs for parts of the Salt Lake City and Boise River drainage basins where serious flood hazards had developed because of recent fires.

1. Contour trenches withstand severe test. The effectiveness of contour-trenching, reseeding and protection from fire and overgrazing as a summer flood prevention measure was again demonstrated at the Wasatch Branch Station during the summer of 1945. During a series of storms on August 18, 19, and 20, the fifteen experimental watersheds of from about 50 to 6,000 acres each, received from 2.44 to 3.33 inches of precipitation. On the night of August 19, rainfall occurred at rates of from 3.72 to 6.84 inches per hour for a 5-minute interval.

The previous maximum 5-minute rainfall intensity recorded in Utah was 5.04 inches per hour during a storm over these same watersheds on July 10, 1936. No floods occurred from the treated watersheds at that time, whereas mud-rock flows issued from four adjacent untreated tributaries.

The record-breaking rainfall on August 19, 1945 also failed to produce any floods from the treated watersheds. Discharges of storm flow from the fourteen basins averaged about 10 cubic feet per second per square mile. Analyses show that virtually all of this run-off came from rain that fell directly into the drainage channels, with only negligible amounts having occurred as surface run-off.

Twelve run-off plots in the head of Parrish Creek representative of the denuded conditions on the areas which produced the destructive floods of 1923-32 in Davis County, yielded 50 times more run-off during the August 18-20 rainstorms, than densely covered aspen plots. No soil has been lost from the aspen plots since they were established in 1934. By contrast, the recent storms removed a quantity of topsoil from the less densely covered plots equivalent to 92 cubic feet per acre.

Other watersheds in the vicinity provided additional evidence of the effect of cover and soil conditions on storm run-off. For example, a destructive mud-rock flow issued from an inadequately treated watershed adjacent to the experimental watersheds. A severely overgrazed watershed about 20 miles to the north also produced a destructive mud-rock flow--the first of its kind and violence in recent geologic times. At Salt Lake City, about 17 miles to the south, three watersheds totaling about 1,000 acres which had been largely burned in 1944, produced floods that caused $350,000 damage in Salt Lake City. The Salt Lake City floods attained discharges of between 3,000 and 4,000 cubic feet per second per square mile or some 300 to 400 times greater discharges than the storm run-off from the experimental watersheds.

The behavior of the experimental watersheds under the impact of the August storms is substantial proof of the effectiveness of the contour trenches and related measures which were applied there for preventing summer floods. There remains, however, the big job of determining the proper design of comparable measures for other watersheds in the region where the infiltration and storage capacities of the plant and soil mantle are known to differ materially from those in the Davis County area. The newly established record of rainfall intensity should be an invaluable aid in the analysis of watershed problems and in the designing of watershed improvement measures.

2. Emergency Report on Salt Lake City Area. A detailed investigation was made of the Salt Lake City flood. This revealed that a very high flood hazard exists on the flood producing watersheds by reason of the drastically reduced plant cover and litter mantle caused by a fire that burned over most of these areas in 1944 and a very efficient gully system cut by the run-off that occurred during the 1945 flood. A report recommending the immediate improvement of the watershed lands by means of artificial reseeding, contour trenching and increased fire control to cost $72,000 was prepared and submitted for approval to Salt Lake City and the Secretary of Agriculture. Salt Lake City officials have not yet reached a decision on the extent of their participation in the program.

As a follow-up of this investigation, Craddock prepared a paper "Salt Lake City Flood, 1945" for presentation at the fall meeting of the Utah Academy of Sciences. This paper is scheduled for publication in 1946 with detailed information regarding both rainfall and run-off records.

3. Emergency Report on Cow Creek Burn. A 16,000-acre burn on and adjacent to the Boise River watershed in 1945 was found to have created a serious sedimentation hazard in the Boise Valley and Mountain Home irrigation projects. The Station cooperated with the regional office in the preparation of an emergency report with recommendations for the immediate reseeding of the burned area under provisions of the Flood Control Act. Secretarial approval of the report was followed by completion of the reseeding job during the late fall.

Progress on Water Supply Problems

Efforts toward the solution of water supply problems were confined to analyses and publication on previously accumulated data and to the maintenance of climatic and run-off records on experimental watersheds which are still in the process of being calibrated for future treatment.

1. Water Supply Forecasting Study. Records of stream flow, precipitation and soil moisture from north- and south-facing aspects in Farmington Canyon provided a basis for a study of the factors affecting the accuracy of forecasting run-off. This study indicates that the accuracy of run-off forecasts can be greatly increased when April 1 snow survey data are supplemented by measurements of moisture already stored in the watershed mantle. It also suggests the possibility of using a single site for obtaining the basic data rather than the present system of extensive snow surveys. Croft reported the results of this study at the Western Snow Survey Conference in Portland and has submitted a technical paper for publication in the PROCEEDINGS OF THE AMERICAN GEOPHYSICAL UNION.

2. Exploratory Studies of Evapo-Transpiration Losses. Soil pit studies in Farmington Canyon show that consumptive use of water by natural cover is roughly equal to the capillary water holding capacity above the wilting coefficient of the soil in the root zone plus the amount of water added by summer rainfall. This loss averages about 14 inches, or about 50 percent of the annual precipitation at intermediate elevation on the Wasatch

Mountains. Following a further check of these losses under natural cover conditions, it is planned to reduce the plant cover to determine if such treatment will result in a reduction of consumptive losses and an increase in the amount of water available for stream flow.

Supplementary to the soil pit tests, an exploratory study was made of water losses by evaporation from stream surface and by transpiration from riparian vegetation along Farmington Creek. These preliminary tests indicate that these combined losses amount to as much as 25 percent of the flow during the hot summer season. Further study is needed to determine the extent to which treatment of the streambank vegetation will result in increased flow.

A note by Croft, "Evapo-transpiration and Riparian Water Loss," was submitted to the Committee on Evaporation and Transpiration of the American Geophysical Union. An abstract of Croft's paper, "Some Recharge and Discharge Phenomena of North- and South-facing Watershed Lands in the Wasatch Mountains," which appeared in the 1945 PROCEEDINGS OF THE AMERICAN GEOPHYSICAL UNION, was accepted for publication in the JOURNAL OF THE AMERICAN METEOROLOGICAL SOCIETY. Croft also published an article in the UTAH FARMER under the title, "Stream Flow Valuable from Range Watershed Lands."

3. Maintenance of Long Range Stream Flow Studies. Records of stream flow and precipitation were maintained on 15 experimental watersheds at the Wasatch Branch for purposes of calibration pending the initiation of watershed treatments to improve the yield of usable stream flow. Comparable records were continued on the sub-basins of Ephraim Creek at the Great Basin as part of the calibration of these areas for future tests of the effects of intensive watershed improvement measures on stream flow. Records of stream flow diversions into the Centerville and Bountiful water spreading basins also were continued.

Soil Stabilization

Stability of the relatively thin mantle of soil on the mountainous forest and range lands of the region is a basic requirement for watershed management as well as other uses of the wildlands. It is essential for regulation of stream flow, for abatement of sedimentation damages and for the production of timber, forage and wildlife.

Attainment of soil stability on the mountainous lands of the region is far from achievement. Soil losses already have occurred in many places and accelerated erosion of slopes and channels due to impairment of the watershed cover by fire, overgrazing and other disturbances is continuing. A major factor that has contributed to the present extent of erosion and one that threatens the stability of other areas is the inability of land managers to detect accelerated erosion in its early stages and to apply corrective measures.

Solutions to the soil stabilization problem require a three-phase research program. One is the development of methods to stabilize and develop new soil on eroded areas. A second phase is the determination of the extent to which the soil and plant cover can be utilized for grazing, timber production and other uses without inducing serious erosion. A third phase is the development of criteria for determining the condition and trend and the run-off and erosion potentials of the watershed lands. Efforts during the past year were limited to the latter two phases.

Surface Run-off and Erosion

A-B Watershed Study. A plant cover survey was made on the A and B watersheds at the Great Basin Branch and a start was made on the analysis of the 30 years of run-off and erosion records.

During the last period of treatment in this study it was intended to reduce the plant cover on Area B to a density of 16 percent as a basis for comparing run-off and erosion rates with those of Area A when it had a comparable cover density. The plant cover inventories, however, show that the density of the plant cover on Area B has not yet been reduced below 25 percent. A preliminary inspection of the run-off and erosion records from the two basins and supplementary infiltrometer tests indicate that the plant cover density must be reduced below 25 percent before substantial run-off will take place. It is expected that further analyses of the records will suggest the need for continuation of heavy grazing on Area B for a year or two in order to complete the present phase of this study.

Surface Run-off and Erosion Potentials. Infiltrometer and rainfall data obtained by the Sevier Flood Control Survey were utilized as a basis for developing the surface run-off potentials of seven plant-soil complexes that occur in the Sevier Lake drainage basin. In this study it was found that relatively slight increases in plant cover, especially above 15 percent, result in great decreases in both amount and frequency of run-off. The findings were reported in JOURNAL OF FORESTRY by Woodward and Craddock.

Further infiltrometer tests were made at the Great Basin Branch Station last summer to determine the effects of soil trampling, plant cover clipping, and season of the year on run-off and erosion rates of the herbaceous cover-limestone soil complex. Due to delays in getting new equipment and training the personnel, it was possible to complete only part of the scheduled tests. Analyses of the data obtained are under way.

Condition and Trend

Efforts on the development of criteria for judging watershed condition and run-off potentials were limited to work on manuscripts and an exploratory field study. A paper by Bailey, "Determining Trend of Range-Watershed Condition Essential to Success in Management," was published in JOURNAL OF FORESTRY. Ellison, Croft, and Bailey started revision work on their manuscript "Judging Condition and Trend on Range-Watershed Lands" in line with Board of Review comments. An editorial by Croft "Reservoirs and Irrigation

Systems Menaced by Silt" was published in the UTAH FARMER. Croft also initiated an exploratory study of soil indicators for use in judging runoff and erosion potentials of the herbaceous cover-livestone soil complex on the A-B watersheds at the Great Basin Branch.

Extension Work

Unusually heavy demands were made on the watershed management and protection personnel for extension work during the past year. Numerous educational show-me trips were made with professional people and others over the experimental watersheds at the Wasatch and Great Basin Branches. Croft was requested to participate in the development of material for teaching watershed management aspects of conservation in the Utah school system. He also helped plan and participated in a series of schools for training Forest Supervisors and Rangers in methods of determining the condition and trend of range-watershed lands.

Program for 1946

During 1946 it is planned to renew studies at the Boise Basin Work Center and to continue efforts at the Great Basin and Wasatch Work Centers. The work program for these areas is as follows:

Great Basin

1. Prepare comprehensive problem analysis and study plans.
2. Improve instrumentation and intensify calibration tests on the Ephraim Creek sub-basins.
3. Continue A-B study with intensive grazing on Area B.
4. Continue the analysis of A-B data.
5. Report on 1945 infiltrometer study.

Wasatch

1. Prepare comprehensive problem analysis and study plans.
2. Improve and intensify calibration tests on Farmington Creek sub-basins.
3. Continue soil pit study of evapo-transpiration losses and water spreading study.
4. Report on Davis County flood control work.
5. Report on 1945 storm.

Boise Basin

1. Prepare problem analysis and study plans.

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STATION PERSONNEL - C. Y. 1945

ADMINISTRATION

Reed W. Bailey	Director
Hazel B. Ballinger	Secretary
Walter E. Mann	Adm. Assistant
Marguerite A. Israelson	Clerk
Leona H. O'Donnell	Clerk
Irene O. Pope	Stenographer
Marselle B. Williams	Stenographer

RANGE INVESTIGATIONS

Grazing Management

Lincoln Ellison	Forest Ecologist
Clark E. Holscher	Forest Ecologist
Selar S. Hutchings	Forest Ecologist
Paul E. Hansen	Agricultural Aid
Eldon Earl Meik	Agricultural Aid
Thomas A. Phillips	Agricultural Aid
Ray H. Bjarnson	Agricultural Aid

Range Reseeding

George Stewart	Forest Ecologist
Alvin C. Hull, Jr.	Forest Ecologist
A. Perry Plummer	Forest Ecologist
Joseph H. Robertson	Forest Ecologist
Richard M. Hurd	Forest Ecologist
Merlin L. Killpack	Range Conservationist
Marion H. Taylor	Agricultural Aid

FOREST & RANGE ECONOMICS

George W. Craddock	Forester (Conservationist)

FOREST & RANGE INFLUENCES

George W. Craddock	Forester (Conservationist)
A. Russell Croft	Forester (Conservationist)
Walter R. Buss	Range Conservationist
Alden Blain	Agricultural Aid
Harry W. Pledger	Foreman C&M

FOREST & RANGE BIOLOGY

Clarence M. Aldous (Coop. Fish and Wildlife Service)	Biologist